



MICRO AUTONOMOUS SYSTEMS AND TECHNOLOGY (MAST) COLLABORATIVE TECHNOLOGY ALLIANCE: PROGRAM ANNOUNCEMENT ADVISORY BOARD MEETING

Technical Area: Microsystem Mechanics

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Outline

Technical Area: Microsystem Mechanics

- Vision
- Technical & Operational Challenges
- Example Research Areas and Issues



Vision and Attributes

Technical Area: Microsystem Mechanics

Maneuverable small-scale platforms (palm-sized and smaller) for moving sensor and communication systems into critical positions, through the air or over terrain

- Soldier friendly, rapidly deployable, and semi-autonomous
- All-weather, all-terrain, military environment
- Mission compatible range and endurance
- Mission compatible payload capacity
- Highly maneuverable through confined spaces
- Expendable or field repairable
- Light weight and easily transportable
- Low-detection capable, self destruct
- Low-cost



Technical & Operational Challenges

Technical Area: Microsystem Mechanics

- Large disturbance environment
- Loss of efficiency on scale
- Large payload to empty weight fraction
- Agility and conformability for congested, confined, and unplanned routes
- Low-power propulsion and actuation requirements
- Large stroke and strain requirements
- Need for integrated analytical modeling capability with applicable constraints



Where are we now?

Technical Area: Microsystem Mechanics

- Biological mechanics studies qualitative in nature: encourage quantitative studies
- Propulsion focus on centralized energy conversion systems: encourage shift to distributed systems
- Multifunctional structures focus on large-scale systems: encourage micro-approach that moves beyond MEMS
- MAV focus on rotary-wing: encourage more emphasis on flapping wing systems
- Lack of integrated analytical modeling capability with applicable constraints: encourage analytical development to address mobility prediction shortfalls.

**Widening Gap Between Theory & Technology
Fundamental Theory & Design Guidelines Needed**



Example Research Areas

Micro Autonomous Systems and Technology

Microsystem Mechanics

- Platform stability & control
- Low Reynolds number aerodynamics
- Bio-inspired sub-systems
- Propulsion and linear actuation
- .
- .
- .

Processing for Autonomous Operation

- Autonomous navigation and control
- Efficient information extraction and utilization
- Dynamic collaborative processing
- Cross-layer communications and network design
- .
- .
- .

Microelectronics

- 3D materials and circuit architectures
- Sensors and actuators for platform and payload
- Smart, multifunctional materials
- Low power devices and small electric power management
- .
- .
- .

Platform Integration

- Microsystem architectures, modeling, and design tools
- Experimentation and analysis
- Sub-system interactions
- Multi-functional packaging
- .
- .
- .



Example Research Topics

Microsystem Mechanics

Aeromechanics (Flight)

Ambulation (Ground Movement)

Propulsion (Fuel to Force)

Bio-Inspired Subsystems

Bio-inspired wings

Multifunctional
structures

Bio-inspired legs

Large stroke,
Linear locomotion

Appendage/joint
optimization

Biomimetic
muscle

Circulatory
Distributed energy

Low Re Aero

Low-Re
rotary-wing
aerodynamics

Vortex dominated
unsteady, low-Re flapping
wing aerodynamics

Platform Stability & Control

HPC nonlinear aeroelastic
multibody analysis with
advanced joint models

Large disturbance
stability & control

Multibody
analysis with
ground contact
models

HPC Microsystem
platform/propulsion
integrated analysis

Propulsion & Linear Actuation

Electrical to
Linear Force
Actuators

Chemical to
Linear Force
Actuators

Approved for Public Release



Summary

- Goal: A maneuverable small-scale platform to move sensor and communication systems into critical positions, through the air or over terrain.
- Fundamental research that...
 - Speaks to the mobility vision and associated attributes
 - Addresses the mobility technical and operational challenges
 - Relates awareness of current mechanics state-of-the-art